LARES

Lexicon Acoustic Reverberance Enhancement System

lexicon

How LARES can Help Meet the Objectives of Good Acoustical Design...

Sound Reinforcement

In this application LARES principles yield an increase in gain-before-feedback of 6 -18 dB. The amount of improvement depends on the number of microphones, loudspeaker channels, and number of Lexicon's Advanced DSP processors. For example, the increase is 15 dB with two microphones, four loudspeaker channels, and one Lexicon 480L Advanced DSP. With two processors and eight loudspeaker channels, the improvement is 18 dB.

With such a large increase in gain before feedback far fewer microphones need to be employed to reinforce any performance, and the reinforcement is hard to distinguish from the natural response of the hall. This type of reinforcement is ideal for boosting a weak vocalist or chorus in a show, improving stage acoustics through added reflected energy, or adding lateral reflections to a hall. In reinforcement applications the LARES software is adjusted to provide maximum intelligibility and minimum reverberation. LARES software also incorporates time delays that can be adjusted to insure that the reinforced sound matches the direct sound.

Acoustic Enhancement

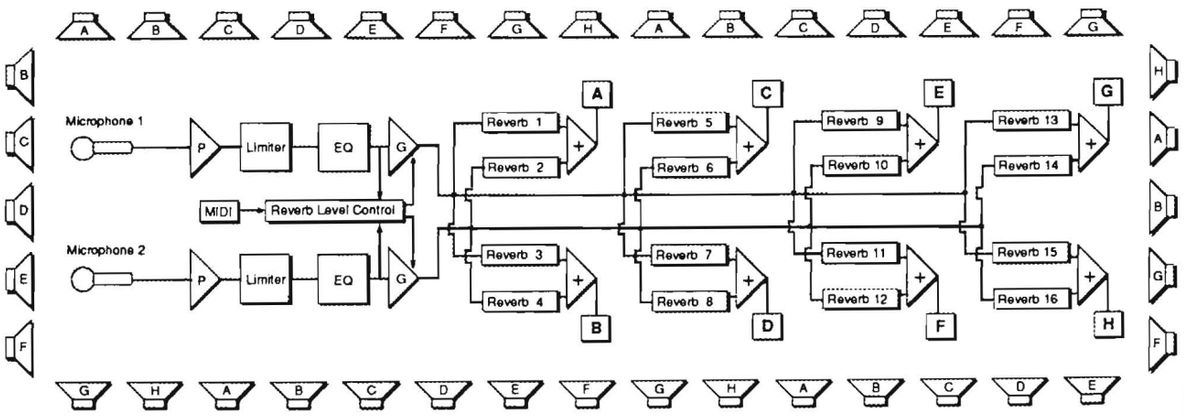
Spaces that can benefit from LARES may vary in size, absorptivity and use. By distinguishing some of the desirable properties of rooms used for listening to music and identifying typical problems encountered in acoustic spaces, we can see how LARES can be integrated to improve the acoustic design.

Reinforcing Early Reflections

The perceived loudness of a sound in a hall depends both on the loudness of the direct sound and on the amount of early reflected energy which adds to the direct sound. The level of the first few strong reflections is determined primarily by the hall geometry. Careful placement of reflecting surfaces in the stage, ceiling and side walls can increase this level somewhat by directing sound energy to the audience. However, the energy directed to the audience by walls or reflectors is generally absorbed, and is not available to create additional level or later reverberation. For this and many other reasons, the total amount of reflected energy depends primarily on the amount of absorption in the hall, which in most halls is proportional to the seating area. The more people you put in a hall the softer the sound will be.

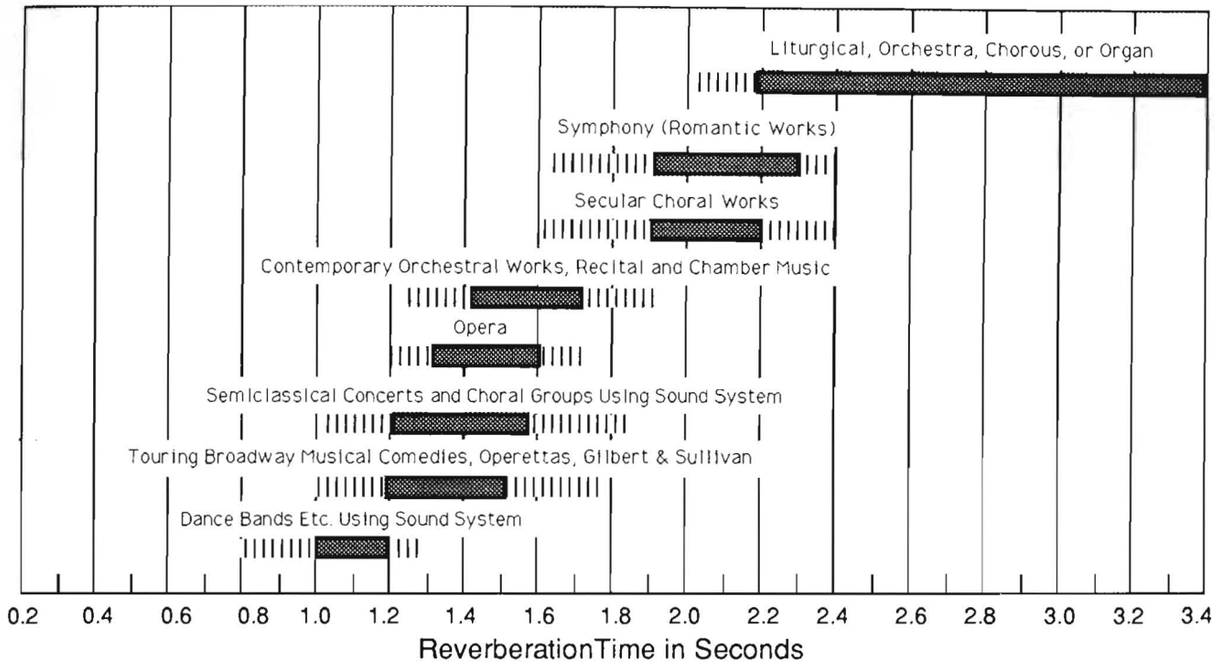
This conflict between hall loudness and seating area is fundamental. It means that small halls will always sound louder than larger ones, and when a small orchestra plays in a large hall, the sound will not have the the impact and richness that enough level can create.

LARES can help enormously with this classic acoustic dilemma. Since the loudspeakers add energy (from the power company) loudness can be increased without the penalty to later reverberation. To significantly increase the actual acoustic level a large amount of acoustic power will be required - at least as much as the orchestra itself! If a conventional sound reinforcement system were used to provide the power, normal microphone spacings of

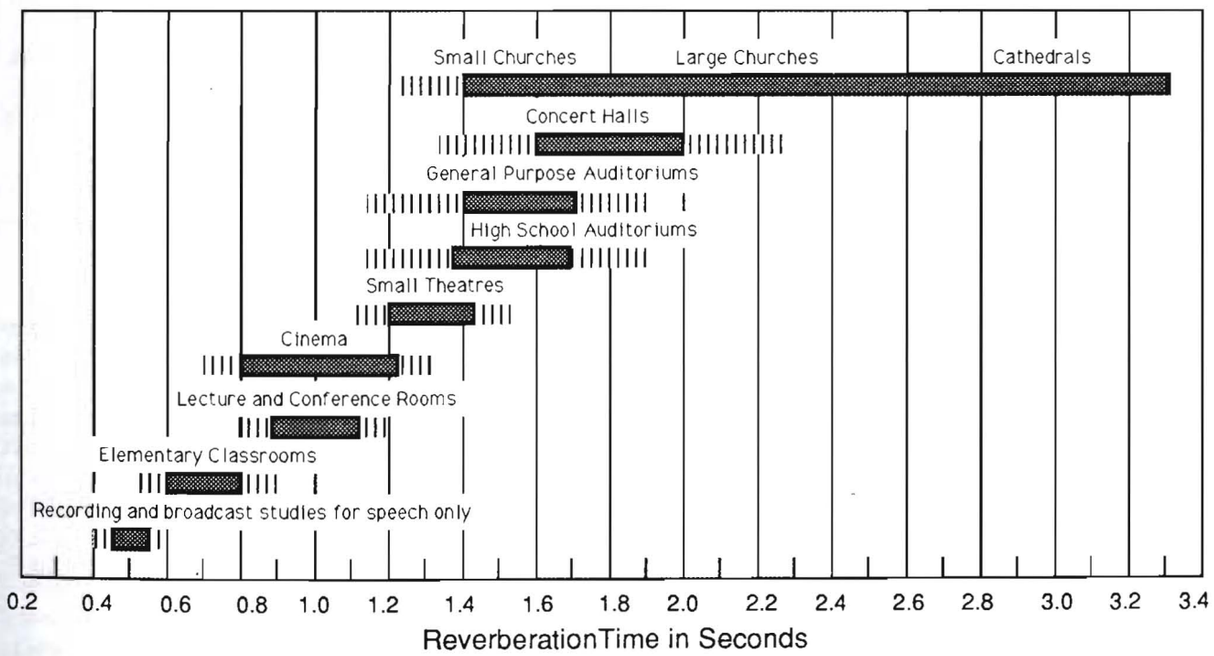


LARES Matches the Space to the Performance...

Reverberance Desired for Various Types of Performance



Reverb Times Typical for Various Performance Spaces



As shown in the charts above, spaces often do not provide reverberation that is well suited for different types of performance. LARES can help spaces achieve reverberant characteristics appropriate for both specific and multipurpose use.

one meter or less would be required to achieve adequate level while maintaining low coloration. In this application, LARES adds both the reinforcement necessary to achieve adequate acoustical power and provides reverberant enhancement. With LARES, a much greater microphone distance can be used eliminating the need for operator intervention or a carefully mixed close microphone array. And unlike a conventional reinforcement system, the energy added from LARES will not be audibly artificial.

Where the initial time delay gap in an existing hall is too large the LARES software and an array of speakers (hidden in the ceiling or disguised as lighting or sculpture) can fill in the missing energy, and do it without any artificial tone color. Such a LARES array can also supply the missing lateral energy in fan shaped designs without any alteration to the desirable sight lines such shapes provide.

In larger spaces, the control of reverberation time and level that LARES provides makes it possible to design a large hall with short audience seating distances and good sight lines while maintaining world class reverberance. Such a hall could be optimized for both symphony and opera, with their very different acoustical requirements. The LARES equipped hall would have the advantage of adjustable acoustics without the expense of motorized drapes or mechanical doors opening to reverberation chambers. Since changes to the reverberation are silent and fast, it is easy to optimize the hall for a particular piece in real time. With the A. R. C. (Automatic Reverberance Control) circuit provided in LARES, it is also possible to achieve a much higher richness and spaciousness in opera productions without compromising dialog.

Enhanced Spaciousness

The vital acoustic property of spaciousness or spatial impression depends on having adequate reflections that come from the sides of the listener. Without electro-acoustics, the direction of reverberation energy depends primarily on the shape of the hall. Halls of rectangular or inverse fan shape have a higher fraction of early lateral reflections than square or fan shaped halls. Once the importance of lateral energy was recognized by acousticians many clever ways increasing it were invented and incorporated into hall designs. For example, ceilings can be designed which project reflected energy primarily to the walls instead of directly down on the audience, and the walls of fan shaped halls can be staggered so sound reflects primarily back across the auditorium.

Such features may increase the lateral fraction, but may not increase the total lateral energy. The features are probably a good idea, but even with them LARES can help considerably. In our experience and that of J. Bradley at the NRC in Canada, spaciousness depends primarily on the absolute strength of the lateral energy, not necessarily in the early lateral fraction. LARES systems are particularly effective in raising the lateral energy, and can be designed to increase the early lateral fraction if this is desired.

We have found that a uniform ceiling array of high quality non-directional speakers combined with our multi-channel digital electronics can successfully create a diffuse sound field with high lateral energy. In the Elgin Theater (Toronto, Ontario, Canada) 56 speakers under the balcony combined with special LARES software and hardware produce a sound field which seems to come from all around the listeners, even if they stand only 5 feet below one of the speakers. There are no echoes even on percussive material, and the sound field does not reduce the intelligibility of speech. The lateral energy increases at least 4 dB when this array is activated, and the increase in spaciousness is impressive. The ceiling seems to disappear, to be replaced by a very convincing illusion of the hall above.

Improved Control Over Late Reverberation Level

Our experience with recorded music has lead us to believe that the ratio of direct sound to reverberant sound is quite critical. Too little reverberant level and music sounds flat and lifeless. Too much makes the sound garbled and muddy. The same appears to be true of halls. In classical acoustics this ratio depends primarily on the geometry of the hall and where you sit, but in the best halls the reverberant sound is never inaudible, and the music is never obscured.

The reverberant level also depends on the size of the hall. In a small hall there may not be adequate audience seating area to absorb the sound. The reverberant level can be high, and the reverberation time can be too short. If the hall designers wish to achieve a reverb time of 1.5 to 2 seconds in spite of the small volume they will probably attempt to reduce the absorption of everything as much as possible, further increasing the reverberant level. This acoustical treatment will make the hall too loud and too muddy, particularly for an audience accustomed to recorded music.

If LARES were incorporated into the design of this small hall, absorption would be added to reduce the natural reverberation to tolerable levels. This may well be easier than it sounds in a new design, since there is no need to make all the surfaces as reflecting as possible. LARES will supply the needed reverberation at a level and a reverberation time appropriate to the music. The architect should work to keep enough absorption in the structure to minimize "muddyness", and to prevent large acoustic differences when the hall is occupied and unoccupied. LARES can minimize the difference in reverberant character due to changing audience numbers in such a space, providing more consistent performances and better listening enjoyment. By reducing the level of the loudspeakers furthest away from the sound sources LARES can also be adjusted so that more of the seats can experience optimum reverberation level.

Enhanced Late Reverberation Time

Another inescapable fact of natural acoustics is that the total absorption usually depends almost entirely on the total seating area, and the reverberation time of a hall depends on the volume of the hall divided by the total absorption. If we want to seat a large number of people the absorptive surface area will be large. If we want to keep the reverberation time constant at 2 seconds as the number of listeners increases we will have to also increase the volume of the hall. Hall volume is expensive, both to build and to heat. Furthermore, if we raise the ceiling overhead reflections will arrive at the audience too late. Reflecting panels will have to be hung to reduce the initial time gap.

In a small hall the problem is reversed. Conventional wisdom for designing such a space would try to make every surface that did not hold the audience as reflective as possible in an effort to increase the reverberation time. However, unless the audience is willing to sit on wooden benches with very little clothing such effort will not increase the reverberation time very much. If we succeed in raising the reverberation time by this means we will also increase the reverberant level and the resulting sound may well be muddy, loud, and unintelligible.

LARES can help both large and small halls enormously. In larger spaces it can provide long reverberant decay without requiring high ceilings. The sound will be louder and better. In small spaces it allows rooms to be constructed with more ordinary materials and acoustically treated with absorption to minimize initial reflections and slap echoes. Once the natural reverberant level has been reduced enough to give good articulation LARES can provide the needed reverberant decay. The decay time and the reverberant level can be manually or automatically adjusted with the LARES A. R. C. (Automatic Reverberance Control) circuit to match the needs of music or speech.

LARES and Stage Enclosures

The problem of providing musicians with the optimum environment for playing is closely related to the problem of sound reinforcement. Normally it is assumed that when musicians cannot hear each other it is because there are too few stage reflections. LARES can directly help this problem. However, we have found that particularly when the stage is small the reflected sound of the musicians' own instruments masks the sound from the rest of the orchestra. In this case the solution is to add absorption to the stage surfaces, and replace the energy lost with a LARES system who's microphones have been carefully balanced to pick up the whole orchestra. Lexicon in conjunction with BB&N has installed a LARES system and about 1000 sqft. of absorption in a small hall in Concord MA, and the improvement in stage acoustics is enormous. Many of the orchestra members spontaneously informed us that it was the first time they had been able to hear the whole orchestra.

In this application the LARES system must produce a high acoustic level in the direct vicinity of the microphones, and the time delays between the direct and the LARES energy had to be short. To achieve short enough delays and adequate gain before feedback the four microphones had to be hung over the orchestra, not out in the hall.

In Corcord, one Lexicon 480L Advanced DSP processor was used to increase optimally timed energy in the stage area. This system provided an "electro-acoustic bandshell" that allowed the musicians in the orchestra to hear each other better and many felt that it improved the performance. Another Lexicon 480L Advanced DSP processor receiving signal from the same microphones was used to provide the long reverberation time needed in the hall. The A. R. C. (Automatic Reverberance Control) circuit automatically tailored the longer reverberation level as different pieces of music were performed.

Applying the Appropriate Technology

In many spaces excellent acoustics can only be achieved through a combination of electro-acoustics and careful application of conventional sound absorption and diffusing surfaces. For this reason Lexicon works directly with acousticians, architects, and sound installers on-site to determine the most appropriate treatment for the given space. We have developed the measurement tools and experience to evaluate the current acoustics and to find the optimum solution. In general, if a room is to be used for both speech and music any problem with unamplified speech intelligibility should be identified and corrected before an electro-acoustic enhancement system is completed.

About Lexicon

In 1971 Lexicon introduced the world to digital audio. Ever since, Lexicon has remained at the forefront of digital audio technology. The Lexicon 224 Digital Reverberation system revolutionized techniques now used daily in the modern recording industry. Today, Lexicon produces a wide variety of digital audio products for both the professional and consumer.

Recent advances in digital signal processing, combined with Lexicon's extensive research in natural acoustics and digital reverberation algorithms, have produced the LARES system and LARES software. This development represents a breakthrough in the way both electro-acoustics and classical acoustics are utilized to enhance the versatility and perceived quality of both the venue and the performance.

LARES -- A Dynamic New Tool for Improving Room Acoustics...

The Lexicon Acoustic Reverberance Enhancement System (LARES) is a method of augmenting the natural direct and reflected energy in halls, performance spaces, places of worship, and spaces that require flexible acoustical character. LARES uses microphones, advanced digital electronics, and loudspeakers to generate energy at the optimal time, loudness, and reverberant decay that greatly enhances the pleasure of listening within an environment. The enormous increase in gain before feedback, and decrease in coloration that LARES provides over conventional sound systems constitutes a breakthrough in acoustical enhancement and sound reinforcement.

The LARES system can:

- Increase the gain before feedback of a conventional distributed sound reinforcement system. The increase in gain that LARES can supply depends on the number of processors and loudspeaker channels employed, but is typically 12 to 18 dB.

- Increase the reverberant level as well as the reverberation time in halls and churches of all sizes. The resulting electro-acoustic reverberation enhancement is both musically convincing and wholly natural sounding. In the current installations, reverberant level (G) has been enhanced by 3 dB or more using only two microphones hidden up to 50 feet away.

- Increase the reverberant time without increasing the reverberant level in spaces that are already too live and muddy.

- Improve the stage acoustics in performance spaces, allowing musicians to hear each other clearly and at the appropriate musical level.

Distinctly Natural Performance

The LARES system is the result of ongoing research and development in the field of reverberant simulation that stems from Lexicon's 20 years of experience in building professional digital audio products. At the heart of the system is Lexicon's Advanced DSP hardware (the Lexicon 480L) and LARES software. LARES software has been specifically developed for acoustic enhancement and reinforcement.

It incorporates sophisticated digital signal processing techniques that overcome the noticeably artificial sound of electro-acoustic systems when significant acoustic feedback is present.

LARES Software -- designed to be experienced, not heard

The unique software used in LARES provides both feedback reduction and/or high quality reverberation. When employed in electro-acoustical applications LARES software is far superior to algorithms designed for use in the recording industry, providing both a remarkable improvement in gain before feedback (at least 12 dB) and reduced tone coloration. A properly installed LARES system also makes the added energy difficult to localize, which allows the acoustician unprecedented freedom when choosing microphone and loudspeaker positions.

LARES can reduce or eliminate many of the difficult problems of classical acoustics, particularly problems where the existing reflected energy is too weak or arrives at the listeners too late. The simple control offered by LARES also allows a multi-use space to be much more successfully shared between groups that require very different acoustics, such as drama and symphony. Unlike fixed architectural acoustic treatments, LARES can be altered in real time with no artifacts. Another unique feature of the LARES software is the A. R. C. (Automatic Reverberance Control) circuit that can distinguish between music and speech and adjust reverberant level automatically. With A. R. C , the LARES system maintains optimum spaciousness and intelligibility for the performance in real time without operator intervention.

Flexible Acoustic Control

The LARES system also provides Lexicon Dynamic MIDI ® control that can be linked with many current lighting and sequencing systems creating possibilities for ambience alteration that until now did not exist.